



The Origin and Development of Backpacks

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Abstract

Briefly outline the historical background, development and evolution process of backpacks, as well as the importance and application of backpacks in different fields. Overview of research methods and structure of the article.

Subject Areas

Sports Sciences

Keywords

Backpack, Origin, Development, History, Design, Function

1. The Origin of Backpacks

The Embryonic Form of Ancient Backpacks

To be honest, there is no quantifiable time in the history of backpacks, nor is there anyone who can prove when someone actually made their first backpack. The origin of human beings can be traced back to the *Homohabilis* period about 1.5 to 2.5 million years ago. *Homohabilis* refers to people who can make tools, and backpacks may have been produced on any day after the appearance of *Homo-habilis*. Below, I will briefly explain the material changes of backpacks in history and the reasons for these changes [1]-[3].

On a certain day in ancient times, people needed to go out hunting and pick wild fruits for their livelihood. At that time, people could carry large prey on their shoulders, but they had to find something to wrap around them for easy carrying compared to fragmented items. So, with the bold attempts of ancient humans, the first “backpack” in history was born.

Based on research from that era, its material could only be made of animal fur or plant weaving. At that time, people may have used fish bone needles or stone needles to sew it together, forming a larger “cloth”. When there were more scattered food or other objects, they could be wrapped inside for easy carrying.

2. The Development of Backpacks

2.1. Early Backpacks

With the development of society, agriculture and handicrafts gradually took shape, and people began to learn how to extract the wild hemp fibers they collected, twist them into hemp threads with stone or pottery wheels, and then weave them into hemp cloth. This also led to the formation of the second generation backpack [4] [5].

During the Spring and Autumn Period and the Warring States Period, students often went on study trips, and this second-generation backpack came in handy. Students can put items into bags made of cloth, which are much lighter and cheaper than fur, which has led people to choose backpacks made of cloth.

There is also a backpack that originated very early, with related woven fabrics appearing as early as the Neolithic Age. Many woven marks were found on the bottom of pottery unearthed from the Banpo site in the Neolithic Age. This backpack is a bamboo back basket. Although this backpack appeared early, among the information I have researched, the earliest and most famous one is the bamboo basket carried by Xuanzang in the Tang Dynasty in the painting “Xuanzang’s Journey to the West to Retrieve Buddhist Scriptures”.

Afterwards, Zhu Fu of the Song Dynasty recorded in his book “Ximan Congxiao” that “the burden is not carried by the shoulders, but by a wooden board in the shape of a central shackle, clamped at the top, and tied with a cloth or leather belt on the forehead, called a back basket.” Although this type of back basket is different from the bamboo woven back basket today, it is the earliest type of back basket in western Hunan.

The surface of bamboo is relatively smooth, making it very convenient to use without the need for polishing. Bamboo also has good anti-corrosion properties, and things made from it can adapt to various humid environments and are durable. Moreover, bamboo baskets usually come in a wide mouthed style and can carry heavier items. During the Song Dynasty, this type of backpack was very popular, and many scholars and martial artists liked to carry one. They could also install a roof on top to prevent rain and avoid the heat. In TV dramas and movies, we can also see scholars or sorcerers carrying bamboo baskets. And now, Yunnan, Xiangxi and other places in China are still using such backpacks [5].

2.2. The Development of Backpacks in the 19th Century

The emergence of new materials: The Industrial Revolution gave birth to many new materials and processes. Early backpacks typically used canvas and leather as the main materials, which were characterized by their strength and durability, making them suitable for daily use and long-term load-bearing carrying. However, with the emergence of new synthetic materials, the material selection for backpacks has become more diverse.

Canvas: Canvas is a thick and durable fabric with high strength and good waterproofing, suitable for making large backpacks. Canvas was widely used in the

production of backpacks in the 19th century.

Leather: Leather is a durable and aesthetically pleasing material commonly used to make the outer layer or details of backpacks. Leather materials provide excellent wear resistance and tear resistance, but they are heavy and costly.

Rubber: Some backpack designs have started using rubber materials as waterproof and protective layers, especially in outdoor activity backpacks where they are widely used.

Synthetic materials and nylon: In the early 20th century, synthetic fibers were invented, making materials such as nylon and polyester new choices for backpack production. These materials are lighter, waterproof, and more durable than canvas, while also being more tear resistant, gradually replacing traditional canvas and leather, especially in modern travel and outdoor backpacks.

Innovation in craftsmanship and design: The Industrial Revolution not only brought new materials, but also promoted the mechanization and scaling of backpack production processes [6].

Machine production: With the advent of mechanization, backpacks no longer rely solely on manual production. The advancement of machine sewing and cutting technology has greatly improved the production efficiency of backpacks, reduced costs, and made backpacks more popular.

Standardized design: After the Industrial Revolution, backpack design began to become more standardized and ergonomic. People have realized that the structural design of backpacks has a significant impact on the comfort and health of users, leading to the emergence of design concepts that place more emphasis on human body adaptation, such as back support systems and pressure reducing shoulder strap designs.

Separation and functional design: With the diversification of social needs, backpack design is gradually developing towards functionality and separation. The interior design of the backpack features multiple compartments, pockets, etc. to better organize items, especially in the fields of travel, military, and academia [7]-[9].

Expansion of Backpack Application Scenarios: With the convenience of transportation brought about by the Industrial Revolution, backpacks are no longer limited to daily load-bearing tools, but have begun to be widely used on various specific occasions.

Military use: With the development of military equipment and tactics, backpacks have become important equipment for soldiers. The design of backpacks has also begun to change to meet military needs, enhancing load-bearing capacity, durability, and functionality.

Outdoor activities: After the Industrial Revolution, with the rise of exploration and outdoor activities, backpacks gradually became essential equipment for activities such as hiking, traveling, and exploration. Designers are starting to consider the portability, waterproofness, and versatility of backpacks.

Students and commuting: With the popularization of education and the advancement of urbanization, backpacks have become a common carry on item for

students and office workers, especially in the 20th century, where student backpacks gradually became one of the cultural symbols [10].

2.3. 20th Century Backpack Innovation

2.3.1. The First World War (1914-1918)

Functional requirements for backpacks: The First World War marked the arrival of modern warfare, and significant changes occurred in the form of military operations. Soldiers need to fight for long periods of time in harsh battlefield environments, and backpacks are not only tools for carrying personal supplies, but also important carriers of military supplies. During this period, backpack design required greater emphasis on load-bearing capacity, durability, and practicality.

Backpack structure: During World War I, soldiers' backpacks were usually made of canvas and leather materials, which were both sturdy and capable of carrying a large amount of equipment. The design focuses on large volume and strong wear resistance. The design of backpacks began to consider the allocation of military supplies and reasonable storage space.

Backpack system: Due to soldiers carrying heavy equipment for long periods of time on the battlefield, backpack design in World War I began to focus on more reasonable backpack systems. During this period, the design of combining shoulder straps and waist belts began to emerge, aimed at dispersing the load and reducing the physical pressure caused by prolonged weight-bearing. The shape of backpacks is gradually becoming more three-dimensional and segmented, making it more convenient for soldiers to quickly access supplies.

Backpack size: Soldiers need to carry enough ammunition, food, water, and other essential items, so the capacity and design of backpacks are more focused on practical needs. Many soldiers' backpacks are designed with multiple compartments for storing different items separately.

Improvement of military backpacks: During the war, the demand for backpacks in the military surged, which also drove improvements in backpack design. Taking the UK and Germany as examples, both countries have developed different types of military backpacks to meet the needs of different battlefield environments.

Backpack design in the UK: During World War I, the UK used a backpack called the "canvas backpack (1914 pattern)". It has a simple design, but is sturdy enough to adapt to long-term combat needs. The backpack has a large capacity and can hold necessary military supplies.

Backpack design in Germany: The "M1910" backpack used by the German military also emphasizes load-bearing capacity. Its uniqueness lies in the combination of shoulder straps and waist belts, which can effectively share weight and reduce the burden on soldiers.

2.3.2. The Second World War (1939-1945)

Modernization and functionalization of backpack design: World War II was a period of thorough reform in backpack design, during which many modern military backpack design concepts were widely applied. War not only tests the physical

strength and endurance of soldiers, but also promotes technological progress in equipment design, especially in terms of convenience, comfort, and functionality.

Load distribution of backpacks: With the increase of combat equipment, the load requirements for backpacks are becoming more stringent, and ergonomic design is being emphasized more. Like the M1936 backpack from the US military and the M31 backpack from Germany, these backpacks have strong carrying systems, and the design of the shoulder straps and waist belts is more in line with the human body curve, which can better distribute weight.

The waterproofness of backpacks: Due to the harsh battlefield environment, the waterproofness of backpacks has become increasingly important. During World War II, backpacks began to use waterproof canvas or coated materials to prevent rainwater infiltration and keep the internal materials dry.

Multifunctionality: The design of backpacks is gradually not limited to storing items, but is also incorporating more functions. For example, the inner and outer bags of a backpack can hold specific items such as ammunition, first aid kits, weapon accessories, etc. The US M-1941 backpack has multiple compartments and pockets designed to meet the needs of different combat environments.

Important backpack design: During World War II, different countries designed multiple iconic military backpacks, which not only played an important role in the war at that time, but also laid the foundation for later backpack designs.

US M-1941 Backpack: This backpack is one of the most classic backpacks of World War II, made of canvas material, with large storage space and multiple compartments. Its design emphasizes the reasonable distribution of weight, and the combination of shoulder straps and waist belts improves the comfort of soldiers' carrying.

German M31 Backpack: This is a backpack widely used by the German military during World War II. It is made of a mixture of leather and canvas materials, and has a compact design that conforms to the German army's rapid mobility tactics. It emphasizes portability, while also possessing excellent durability and load-bearing capacity.

Soviet backpacks: The backpack design used by the Soviet military during World War II was also very distinctive. Although not as complex as the US and German armies, it also had strong durability and versatility. Soviet backpacks were usually simple and practical, capable of accommodating basic military supplies.

The transition from military to civilian: After World War II, with the end of the war, many military backpack designs were shifted towards the civilian market. Especially in outdoor activities such as travel and mountaineering, backpacks used during wartime have gradually been accepted by the civilian market and improved, becoming the prototype of modern hiking bags, travel backpacks, and so on.

2.4. The Popularity of Backpacks in Commercialization and Daily Life

2.4.1. Functional Transformation of Backpacks

The growth of tourism demand: With the popularization of mass tourism, espe-

cially in regions such as Europe and America, more and more people are participating in activities such as hiking, camping, and long-distance travel. This trend has driven the expansion of the backpack market. Early backpacks were mainly used in schools and daily life, but in the 1950s, the functions of backpacks began to extend to more outdoor uses.

The comfort and durability of backpacks: Due to the need for backpacks to carry more items during long-term outdoor activities, designers have begun to pay attention to the comfort and durability of backpacks. In the late 1950s, the backpack carrying system (such as shoulder straps, waist belts, etc.) began to be improved, adopting more ergonomic designs to reduce carrying pressure and enhance the carrying experience.

2.4.2. Introduction of Multi Functional Design

Partition and zipper design: With the increasing use of backpacks, backpack design has begun to pay more attention to structural diversity. In order to adapt backpacks to different travel needs, designers have started adding functional designs such as dividers, zippers, and multiple pockets to backpacks. In this way, not only can items be better organized to avoid clutter, but also the safety of items can be improved.

Multi pocket design: In the 1960s, many backpacks began to incorporate multiple external pockets for convenient storage of water bottles, maps, food, and other small equipment. This design makes the backpack not just a storage bag, but also an intelligent device that can help travelers access items more conveniently.

2.4.3. The Rise of Outdoor Sports and Mountaineering Backpacks

The rise of mountaineering and hiking: In the 1960s, with the popularity of mountaineering, especially in the United States and Europe, backpacks specifically designed for mountaineering began to become a market demand. The design of mountaineering backpacks places more emphasis on adjusting the center of gravity and storing special equipment. For example, backpacks are now equipped with buckles for attaching climbing ropes, ice axes, and other tools.

The embryonic form of modern mountaineering backpacks: At this time, the structure of mountaineering backpacks became increasingly refined, not only enhancing load distribution, but also improving durability and waterproofness. Many brands have started developing backpacks with specialized purposes, such as multifunctional backpacks for camping and lightweight backpacks for hiking.

2.4.4. The Use of Innovative Materials

The application of canvas and nylon: With the advancement of technology, especially the emergence of lightweight and sturdy synthetic materials such as nylon, the durability and weight of backpacks have been greatly improved. Materials such as nylon and canvas are not only lightweight, but also have good tear resistance and waterproof performance, making backpacks perform better in long-term use and harsh environments.

Innovative support system: In addition, the backpack's back support system has

improved during this period. For example, some backpacks have started to incorporate metal frames or rigid backboards, allowing the weight of the backpack to be more evenly distributed to the back and waist, reducing the burden on the shoulders.

2.4.5. Branding of Backpack Design

Brand Rise: From the 1950s to the 1970s, many well-known outdoor brands began to emerge. For example, brands such as Osprey, The North Face, Kelty, Gregory, etc. have gradually become representatives of backpack design. These brands have not only innovated in functional design, but also made significant improvements in material selection and comfort.

Specialization and market segmentation: During this period, backpacks began to move from a single “mass market product” to segmented markets. Different brands have designed specialized backpacks for different purposes such as mountaineering, hiking, camping, travel, etc., gradually meeting the diverse market demands.

2.4.6. The Evolution of Backpack Aesthetics and Fashion

The appearance design of backpacks: In addition to functionality, the appearance of backpacks is also becoming more fashionable. Especially in the late 1960s, backpack design began to be influenced by trends, and innovations in color, material, and shape gradually attracted the attention of more young people. Some brands are beginning to try combining backpacks as fashion accessories with sports equipment, and backpacks have gradually become a symbol of personality and lifestyle.

2.5. The Combination of Technology and Backpack Design

2.5.1. Progress in Materials Technology

Nylon and Polyester: These two synthetic fibers are widely used in modern backpacks and have strong tensile strength, wear resistance, and waterproofness. Nylon is particularly known for its durability and elasticity, while polyester fibers are known for their lightweight, UV resistance, and moisture resistance. Both can effectively resist wear and environmental factors.

High performance synthetic materials, such as Cordura® (High strength nylon) and Dyneema® (Ultra high molecular weight polyethylene), these materials are more durable and lightweight, and can maintain the integrity and comfort of backpacks in extreme environments.

Elastic fabric and air mesh: New types of elastic fabric and breathable mesh materials are applied to the back and shoulder straps of backpacks, providing better breathability and comfort, reducing the accumulation of sweat on the back, and improving the comfort of long-term carrying.

Lightweight composite materials: With the development of lightweight technology, backpack frames and structures are gradually using composite materials such as carbon fiber or aluminum alloy to reduce weight while maintaining strength.

2.5.2. Improvement of Waterproof Technology

TPU (thermoplastic polyurethane) coating: TPU coating can provide excellent waterproofing and is more environmentally friendly and durable compared to traditional PVC materials. Many high-end backpacks use this coating technology, which can effectively prevent moisture infiltration.

Waterproof zipper: waterproof zipper with strong sealing can effectively prevent moisture from entering the inside of the backpack in rainstorm. Some backpack brands also use their own developed waterproof zipper system.

Sealing process: In addition to waterproof coating, the sewing process of the backpack has also been improved, using technologies such as hot pressing and ultrasonic welding to make the backpack less prone to water leakage at the sewing point, and the overall waterproof performance has been significantly improved.

Completely Waterproof Bag Body Design: Some specialized outdoor backpack brands have launched a completely waterproof design, with no seams on the bag body, using a single large waterproof material or heat sealing technology to ensure that the items inside the bag can remain dry even in extreme environments.

2.5.3. The Rise of Smart Backpacks

USB charging port: Many modern backpacks come with built-in USB ports, allowing users to charge their phones, tablets, laptops, and other devices anytime through the battery pack inside the backpack. For people who travel for long periods of time or frequently need to work on the go, USB charging backpacks are extremely convenient.

Solar powered backpack: The integration of solar panels enables the backpack to provide power to electronic devices through solar energy. This feature is very suitable for users who engage in outdoor activities, travel, and long-term outdoor work. It can charge the built-in battery of the backpack through sunlight exposure.

Bluetooth and intelligent tracking: Some smart backpacks are equipped with Bluetooth functions, which can be connected to smartphones for remote locking, finding backpack location and other operations. Some high-end backpacks are even equipped with GPS trackers to prevent backpack loss.

Built in LED lights and display screen: Some backpacks are equipped with built-in LED lights for night lighting. Even some backpacks have small display screens on the outside that can show time, weather information, or personalized messages.

Intelligent temperature control and heating function: Some smart backpacks also have built-in temperature control systems that can adjust the temperature inside the backpack to maintain comfort. This is particularly useful for outdoor activities in cold weather, and some backpacks can even be heated to protect the electronic devices inside the backpack.

2.5.4. Ergonomics and Comfort

Multi segment shoulder strap adjustment system: It can adjust the length of the shoulder strap according to the user's body shape, making the backpack more snug and reducing the burden on the shoulders and spine.

Belt and chest strap: High end backpacks typically come with adjustable belts and chest straps to evenly distribute weight, reduce pressure on the shoulders, and enhance carrying stability.

Breathable design on the back: Mesh materials are usually used in the back area, or breathable foam is added to improve breathability and maintain comfort when carrying for a long time.

2.5.5. Future Backpack Design Trends

With the continuous advancement of technology, backpack design will pay more attention to intelligence and personalization. Future backpacks may have more cutting-edge technologies, such as augmented reality (AR) displays, intelligent voice assistants, automatic temperature adjustment, and may even be connected to users' biological signals to provide more intelligent feedback and support.

3. The evolution of Backpack Design

3.1. Carrying the Innovation of the System

3.1.1. The Evolution from Simple Shoulder Straps to Modern Backpack Systems

Traditional shoulder straps: Early backpack designs relied solely on simple shoulder straps to share the weight of the backpack. Shoulder straps were usually narrow and had low comfort, causing pressure on the shoulders and back when carrying heavy loads.

Basic backpack system (mid-20th century): With the popularity of mountaineering and hiking activities, backpack design began to focus on comfort and functionality. Gradually introduced designs such as wide shoulder straps and thick shoulder pads to alleviate shoulder burden and improve the weight-bearing experience.

The rise of modern backpack systems (21st century): Modern backpack systems place more emphasis on overall weight distribution and comfort, especially the design of waistbands, air back panels, and adjustable shoulder straps, which enable backpacks to effectively share pressure on the back, shoulders, and waist, reducing fatigue caused by long-term use.

3.1.2. Key Technologies of Modern Backpack Systems

Airflow backplane: This kind of backplane design usually uses mesh material or foam structure with gaps to facilitate air circulation, help heat dissipation and reduce moisture in the back. Especially in summer mountaineering and hiking, the breathability and comfort of the back are significantly improved.

Adjustable shoulder straps: The adjustable shoulder strap design allows the backpack to be adjusted according to the user's body shape, and suitable carrying methods can be found for different shoulder widths and heights, ensuring comfort and stability.

Belt design: Modern backpacks often come with a thick, adjustable belt system that helps transfer weight to the hips and waist, rather than relying solely on the

shoulders, thereby improving load-bearing capacity and comfort. Especially in mountaineering backpacks, the belt is often equipped with a lumbar pad and a tension strap to help better fit the body and reduce pressure on the back and shoulders.

Back support frame (inner and outer frame design): Modern backpacks are increasingly adopting inner or outer frame designs. The inner frame is usually made of lightweight aluminum alloy or plastic, which can enhance the stability of the backpack while ensuring comfort, reducing sagging and shaking. The outer frame pays more attention to load distribution and is suitable for activities that require carrying heavy objects for a long time.

Intelligent adjustment and ergonomics: Modern backpacks also adopt some intelligent designs, such as automatic adjustment of shoulder or waist strap tension, adjustable backpack board and back curve, etc. These designs combine ergonomics to minimize discomfort and fatigue to the greatest extent possible.

3.1.3. Differences and Progress in Various Backpack Designs

Mountaineering backpack

Load bearing requirements: Mountaineering backpacks usually need to carry heavier items such as tents, sleeping bags, food, etc. Therefore, the carrying system must be able to evenly distribute the weight, especially during long periods of hiking or climbing.

Characteristics of the backpack system:

Emphasize the design of the waist belt and back frame to transfer most of the weight to the hips, reducing shoulder pressure.

Adopting an air back panel and breathable design to enhance comfort, especially during high-intensity sports.

Adjustable shoulder straps, chest straps, and waist belts to accommodate different body types and activity needs.

Travel backpack

Load requirements: Travel backpacks are mainly used for short-term travel or city crossing, with relatively light loads, but comfort and practicality still need to be considered.

Characteristics of the backpack system:

The design pays more attention to comfort, and the carrying system is usually relatively simple. The shoulder strap width is moderate, and it is equipped with an appropriate waistband to increase stability.

Some travel backpacks are also equipped with adjustable carrying systems and multiple storage compartments, making it easy to organize clothing and other travel essentials.

Due to its light weight, backpacks usually do not require complex support frames or air cushion backboards, and comfort and breathability remain the focus of design.

Computer package

Load bearing requirements: The computer bag has a relatively light load, mainly carrying laptops, files, office supplies, etc. The carrying system focuses more on

comfort and stability.

Characteristics of the backpack system:

More emphasis is placed on portability in design, usually equipped with padded shoulder straps and backboards to enhance comfort.

High end computer bags often incorporate breathable designs and thick waistbands to meet the comfort needs of long-term carrying.

Internally, computer bags usually have separate laptop compartments with soft cushions for protection of electronic devices.

Innovation of the Future Carrying System

Intelligent backpack system: With the development of technology, future backpacks may incorporate more intelligent technologies. For example, built-in sensors detect weight and automatically adjust the tension of the carrying system, support health monitoring (such as heart rate, posture, etc.), and even provide personalized adjustments through the app.

Lightweight materials and high-strength design: In order to reduce the weight of the backpack itself, manufacturers may use lighter and stronger materials such as carbon fiber, nanomaterials, etc. to ensure that the backpack maintains an extremely light weight without sacrificing comfort and durability.

More personalized design: With the increasing demand of consumers for backpack design, personalized and customized backpack systems may become a trend. You can choose different carrying systems, comfort adjustment methods, and backpack structures according to personal needs.

3.2. Ergonomics and Functional Design

3.2.1. Design of the Carrying System

Shoulder strap design: The shoulder strap should be wide and conform to the contour of the human shoulder. A wider shoulder strap can evenly distribute the load and reduce pressure on the shoulders. At the same time, the material of the shoulder strap should have breathability and appropriate cushioning effect to reduce discomfort caused by long-term carrying. The shoulder straps should be adjustable to ensure they match the user's body shape.

Belt design: A belt is crucial for sharing weight, especially for heavy backpacks. The design of the waist belt should conform to the structure of the human pelvis, which can transfer most of the weight to the waist, thereby reducing the burden on the shoulders. The belt needs to have appropriate thickness and width to fit the hips and distribute pressure.

Backboard design: The backboard should be designed according to the natural curve of the spine, providing support and reducing the burden on the back muscles. Breathable holes or mesh materials can be designed on the backboard to enhance ventilation and prevent excessive sweating on the back. In addition, a flexible support frame can also be added to the backboard to enhance stability under load.

Chest strap design: The chest strap can help keep the shoulder strap stable and prevent the backpack from slipping, which is especially suitable for heavier backpacks. The chest strap design should conform to the natural curvature of the chest

and should not be too tight to avoid affecting breathing.

3.2.2. Load Distribution and Center of Gravity Adjustment

Load balancing: The design of a backpack should distribute weight evenly on the back as much as possible, especially through shoulder straps, waist belts, and backboards to distribute the load reasonably. The ideal backpack design should ensure that the center of gravity of the load is aligned with the spine, avoiding excessive bending or twisting of the spine.

Internal partition design of backpack: Reasonable internal compartments and zones can help users allocate item positions reasonably and reduce one-sided load. Important items can be placed near the upper part of the back, while heavy objects should be placed as close as possible to the bottom and middle of the backpack to maintain stability when carrying weight.

Load adjustment function: Some high-end backpack designs are equipped with adjustment functions, such as back load adjustment, waist belt height adjustment, etc., allowing users to adjust the center of gravity and load distribution of the backpack according to personal needs.

3.2.3. Breathability and Comfort

Breathable design: Use breathable mesh, hollow design, or air circulation slots on shoulder straps, backboards, and other areas to promote air circulation and avoid sweating on the back caused by long-term carrying. Breathable design can keep the skin dry and enhance the comfort of carrying.

The use of cushioning materials: Appropriate cushioning materials can effectively reduce the impact of carrying, especially in uneven terrain or during exercise, which can reduce pressure on the back, shoulders, and waist. Common buffer materials include memory sponge, EVA foam, etc.

3.2.4. The Weight and Material of the Backpack

Lightweight design: Try to use lightweight and durable materials to reduce the weight of the backpack, so that users can bear heavy objects without being burdened by the weight of the backpack itself. For example, lightweight materials such as high-strength nylon and polyester fibers can be used to improve the strength and durability of backpacks.

Wear resistant and waterproof materials: The external materials of the backpack should have certain wear resistance and waterproof properties to cope with the challenges of different environments and weather conditions, and enhance the service life of the backpack.

3.2.5. Regulation and Personalization

Adjustable design: Due to the significant differences in body shape among different users, backpacks should have adjustable shoulder strap length, waist belt width, and chest strap position. Through these adjustment functions, users can precisely adjust the adaptability of the backpack according to their personal needs.

Different size selection: The size of the backpack should be chosen according to

its purpose and the target user's body type. For example, outdoor backpacks, travel backpacks, daily backpacks, etc. can be designed with different sizes and capacities based on differences in body shape.

3.2.6. Dynamic Adaptability and Intelligent Carrying

Dynamic backpack system: Some high-end backpacks use a dynamic backpack system, which adopts adjustable internal support frames, suspension systems, etc., allowing the backpack to dynamically adjust according to the user's activities, maintaining stability and comfort. For example, the suspension system in an outdoor backpack can adjust the force point of the backpack according to changes in gait, reducing pressure on the spine.

Intelligent backpack system: Some modern backpacks use intelligent sensors to monitor the weight distribution and carrying status of the backpack, and even help users adjust the usage of the backpack by connecting to mobile applications, further improving comfort and functionality.

3.2.7. Comfort during Long-Term Use

Massage pads and pressure dispersion: Some backpack designs incorporate massage pads or special pressure dispersion designs on the shoulder straps and backboards to reduce pressure concentration by increasing the contact surface, thereby increasing comfort during long-term wear.

Regular adjustment: When using for a long time, users should regularly adjust the tension of shoulder straps, waist belts, etc. to avoid excessive pressure concentrated in a certain area.

3.3. Sustainability and Environmental Design

3.3.1. The Use of Environmentally Friendly Materials

Recycled materials: Many brands have started using recycled polyester fibers (RPET) or recycled nylon, which typically come from recycled plastic bottles or discarded fishing nets. This approach not only reduces plastic waste, but also effectively lowers energy consumption during the production process.

Natural materials, such as organic cotton, hemp, bamboo fiber, and other natural fibers, are used for the outer shell, lining, and straps of backpacks. These materials often do not contain harmful chemicals and are biodegradable, making them environmentally friendly.

Environmentally friendly leather: The traditional leather production process often involves a large amount of water consumption and the use of harmful chemicals. The emergence of environmentally friendly leather has reduced these environmental burdens. Plant tanned leather, recycled leather, and innovative materials such as "apple leather" (made from apple by-products) have become alternative options.

3.3.2. Reducing Carbon Footprint

Local production: In order to reduce carbon emissions during transportation, some brands choose to set up production bases in areas close to their main mar-

kets, reducing emissions from logistics and transportation processes.

Energy efficiency: Using renewable energy sources such as solar and wind power to supply electricity, optimizing the energy use of production lines, and reducing energy consumption and pollution emissions in factories.

3.3.3. Modular Design and Durability

Modular design: This design allows users to replace some components of the backpack according to their personal needs, such as detachable shoulder straps, adjustable backpack bag openings, etc. In this way, the lifespan of the backpack is extended, and consumers do not need to purchase new backpacks frequently.

High durability: More and more brands are focusing on using more durable materials and processes to reduce backpack wear and tear. Durable backpacks not only meet consumer demands in terms of quality, but also help reduce waste and resource wastage.

3.3.4. Design Simplicity, Combining Functionality and Aesthetics

Multi functional design: Modern backpacks often have multiple functions, such as waterproof, antibacterial, expandable capacity, etc., which makes backpacks more practical and extends their lifespan.

Lightweight design: Lightweight backpacks not only reduce the use of materials in the manufacturing process, but also make consumers more comfortable and adaptable to a wider range of usage scenarios.

3.3.5. Transparency and Social Responsibility

As consumers become increasingly concerned about brand social responsibility, backpack brands are also promoting supply chain transparency. For example, many companies disclose information such as the source of their raw materials, the conditions of their production factories, and whether they comply with fair trade standards to increase consumer trust in their brands. This transparency helps brands establish long-term customer relationships and encourages other businesses to adopt more environmentally friendly and socially responsible practices as well.

3.3.6. Circular Economy and Recycling Plan

Some backpack brands have also adopted a circular economy model, encouraging consumers to return their old backpacks for reuse or refurbishment through recycling programs. For example, when consumers purchase a new backpack, the old backpack can be recycled or repaired and resold, reducing the generation of waste. Meanwhile, some brands offer discounts or rewards to encourage consumers to participate in recycling programs.

3.3.7. The Growth of the Eco-Friendly Backpack Market

With the increasing attention of consumers to environmental protection, the market demand for eco-friendly backpacks is also growing. Especially among young consumers, many are willing to pay a premium for products that meet environmental standards. Many brands have responded to this trend by launching back-

pack series that align with sustainable development concepts, which not only enhances brand image but also receives positive market feedback.

3.3.8. Technological Innovation

The backpack industry is constantly exploring new environmental protection technologies. For example, innovations such as using more environmentally friendly dyeing processes, low water consumption production methods, and even biodegradable synthetic materials continue to drive the backpack industry towards sustainable development.

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Conflicts of Interest

The author declares no conflicts of interest.

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